

## GPS Receiver System and Method

### FIELD

The field of the present invention is electronics. More particularly, the present invention relates to receivers for wireless communications devices.

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### BACKGROUND

Demands placed on wireless communications devices are continually increasing. While the number of functions required of wireless communications devices is increasing, consumers are simultaneously demanding lower cost devices with longer use times between battery charging and which are lighter and smaller than previous devices.

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Particularly, there is a high demand for adding global positioning systems (GPS) services to the functions of wireless communications devices. More specifically, consumers want a wireless communications device that has both GPS and PCS services or GPS and cellular CDMA, among other services. Additionally, some government agencies, e.g., the FCC in the United States, are mandating that position location functionality be incorporated into wireless communications devices which is able to meet a specific accuracy. GPS is one solution which can meet this requirement and operates at a frequency of 1575.42 MHz, as is well known in the art. PCS is a wireless communication band at a frequency of about 1960 MHz, as is well known in the art.

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25 Cellular CDMA is a wireless communication system at a frequency of about 870 MHz, as is well known in the art.

In a typical wireless communications device receiver, an antenna assembly receives a radio frequency (rf) signal from the air. The antenna assembly may include an antenna, an antenna matching circuit and any other component required to receive the rf

5 signal. The signal is a series of electromagnetic fields travelling in waves in the air at a certain frequency, the radio frequency. The waves carry energy. The antenna captures some of this energy so that the energy can travel along a guided path. The guided path may be a wave guide or metal conductors, such as wires or strips of metal, known as microstrip lines, on a substrate, among other things.

10 The signal captured by the antenna may have waves of frequencies other than the desired rf. Filters are used to block any signal component at frequencies other than the desired rf. Thus, the rf signal is made to travel through one or more filters to select a desired frequency or range of frequencies. Also, the desired rf signal may be very weak. Amplifiers are used to magnify the strength of the rf signal. Thus, the rf signal is made to 15 pass through one or more amplifiers.

The rf signal carries information. The information is contained in changing phase, amplitude or frequency of the rf signal. To get this information out of the signal, the signal is typically compared to an rf signal of constant phase, amplitude or frequency. The constant phase, amplitude or frequency rf signal is known as a local oscillator signal 20 and comes from a precise rf signal generator in the communication device, known as a local oscillator. The local oscillator signal is combined with the rf signal by a device known as a mixer. The mixer produces sum and difference signals of the local oscillator signal and the rf signal. This process of producing sum and difference signals from two initial signals is known as mixing, producing mixed signals.

25 Commonly, the rf signal is mixed once down to an intermediate frequency (IF) signal and then again down to what is known as a baseband signal. Both the IF signal and the baseband signal are lower frequency signals. A baseband signal contains the coded information that the original rf signal was carrying. When the rf signal is mixed down to

5 an IF signal, one of the mixed signals is typically chosen to carry the message contained in the rf signal. This chosen signal is known as the IF signal. The IF signal is typically selected by an IF filter designed to transmit the IF signal only.

After the IF filter, and possible further filtering and amplification, the signal encounters another mixer, where it is mixed with another local oscillator signal. This

10 local oscillator signal has a frequency equal to the IF signal frequency. Again, sum and difference signals are produced. The signal of interest at this point is known as the baseband signal. The baseband signal is also known as the “zero frequency difference” signal, even though the frequency of the baseband signal is not zero. Its frequency is the frequency of the coded information that it carries. The baseband signal is then decoded to  
15 reveal whatever information was transmitted. It will be appreciated that the signal may be mixed directly from an rf signal down to baseband. In this case, there is no IF signal.

When GPS service is added to a wireless communication device, the GPS receiver portion typically has each of the above devices to process the GPS rf signal. In various designers’ attempts to combine PCS and GPS services in one device, separate mixers  
20 have been used for down converting PCS to an intermediate frequency (IF) and for down converting GPS to an IF. Additionally, separate IF filters have been used to filter the IF signal after down conversion to IF and before down conversion to baseband. The same is true of attempts to combine GPS and cellular CDMA. Separate mixers and IF filters have been used. Thus, the cost, size and power consumption of prior art GPS enabled devices  
25 is significantly more than that of those without GPS services.

## SUMMARY

The cost, size and power consumption of prior art GPS enabled wireless communication devices is significantly more than that of those without GPS services.

Accordingly, it would be desirable to have an rf communication device, particularly a

10 PCS wireless communication device and a cellular CDMA wireless communication device with cost effective and size and power consumption efficient GPS functionality.

Generally, the invention allows GPS functionality to be added to a wireless communication device in an efficient and cost effective manner. Briefly, the present

invention has a common mixer constructed to be used for a GPS signal and another

15 signal, such as a PCS signal. In one embodiment, a common mixer and IF filter are used for both PCS and GPS signals. In another embodiment, a band select switch may be used to select either the PCS signal or the GPS signal. Alternatively, a duplexer or diplexer may couple the GPS signal and the PCS signal to the common mixer. In this way, a common mixer is enabled to be used for both GPS and PCS.

20 A dual band local oscillator may be configured to output a local oscillator signal facilitating selection of a GPS IF signal, a PCS IF signal or a cellular CDMA IF signal,

using a common IF filter. In another embodiment, both the GPS low noise amplifier

(LNA) and the PCS LNA may be switched on and off depending upon whether GPS or PCS reception is selected. In another embodiment, a common IF filter may be used for

25 both GPS and cellular CDMA signals.

This reuse of a mixer and an IF filter desirably contain the cost, size and power consumption of a GPS/PCS enabled wireless handset.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, tables and attachments, in which:

Fig. 1 is a block diagram of a receiver portion in accordance with the present  
10 invention.

Fig. 2 is a block diagram of a receiver portion showing a common IF filter for  
filtering a cellular CDMA IF signal and a GPS IF signal in accordance with the present  
invention.

Fig. 3 is a block diagram of a receiver portion showing use of a GPS/PCS diplexer  
15 in accordance with the present invention.

Fig. 4 is a block diagram of a receiver portion showing use of a GPS/PCS  
duplexer in accordance with the present invention.

Fig. 5a is a block diagram of a receiver portion showing an example circuit for  
powering up and down of the GPS and PCS LNA's in accordance with the present  
20 invention.

Fig. 5b is a graph showing a frequency response of an active mixer in accordance  
with the present invention.

Fig. 5c is a graph showing a frequency response of a passive mixer in accordance  
with the present invention.

Fig. 5d is a block diagram showing reuse of a passive mixer in accordance with  
the present invention.

Fig. 6 is a flow chart showing a method for mixing a GPS signal and a PCS signal  
in accordance with the present invention.

5 Fig. 7 is a flow chart showing an alternative method for mixing a GPS signal and  
a PCS signal in accordance with the present invention.

#### DETAILED DESCRIPTION

10 Referring now to Fig. 1, a receiver portion 10 is shown. Receiver portion 10 may  
be used, for example, as a receiver portion for a wireless communication device. In a  
preferred embodiment, the receiver portion 10 is arranged with other known components  
to constitute a CDMA wireless communication device with integral GPS compatibility.

15 Advantageously, a single mixer 46 is used for both of the PCS and the GPS signals for  
down conversion to an IF. Using a single mixer to provide GPS and PCS functionality in  
a wireless communication device enables a lower cost, smaller size and lower power  
consumption wireless communication device having PCS and GPS functionality.

Fig. 1 is a schematic block diagram of the major assemblies of a multiband  
receiver portion 10. A GPS antenna 14, for receiving a GPS signal, is coupled to a first  
20 low noise amplifier (LNA) 18, for amplifying the GPS signal. The first LNA 18 is  
coupled to a first band pass filter (BPF) 22 for filtering the GPS signal. The first BPF 22  
is coupled to a first input 34 of a band select switch 38. The band select switch 38 selects  
between the GPS and the PCS bands, responsive to a GPS control signal, generated by a  
GPS control signal generator 20.

25 The PCS signal 50 may be received from a PCS duplexer (not shown), which is  
coupled to a second LNA 54. The second LNA 54 is coupled to a second BPF 62 for  
filtering the PCS signal. The second BPF 62 is coupled to a second input 64 of the band  
select switch 38. An output 42 of the band select switch 38 is coupled to a first input 44  
of a first mixer 46. This mixer is used for down converting both GPS and PCS signals to

5 an IF signal, providing advantages over the prior art. An RF output 15 (also known as the  
local oscillator (LO) signal) of a dual band local oscillator 66 is coupled to a second input  
17 of the first mixer 46. The first mixer 46 mixes the LO signal with either the PCS  
signal or the GPS signal to produce the IF, responsive to the GPS control signal generated  
by the GPS control signal generator 20. The GPS control signal selects which of the local  
10 oscillator signals is received by the first mixer 46.

Preferably, a third BPF 21 filters the signal whether it is a GPS signal or a PCS  
signal. Due to the similar characteristics of CDMA and GPS signals it is possible for an  
IF signal indicative of a GPS signal and an IF signal indicative of a CDMA signal to pass  
through the same IF filter 21. Preferably, the IF filter 29 (21??) is optimized for CDMA.

15 Thus, an output 19 of the first mixer 46 is coupled to the third BPF 21. This output 19  
comprises an IF signal indicative of either the GPS signal or the PCS signal, depending  
upon which of the GPS signal and the PCS signal is selected by the band select switch 38,  
which is controlled by the GPS control signal generator 20. Preferably, the same BPF 21  
is used, for filtering the IF signal whether the IF signal is indicative of the GPS signal or  
20 of the PCS signal, providing advantages over the prior art.

The GPS control signal generator 20 is also preferably coupled to the LO 66. The  
GPS control signal generator 20 thus selects which LO signal is mixed by the first mixer  
46 with either the GPS signal or the PCS signal. If the GPS control signal is on, the LO  
signal used for down converting the GPS signal to an IF frequency is enabled. If the GPS  
25 control signal is not on, the LO signal used for down converting the PCS signal to an IF  
frequency is enabled. In this way, the same mixer 46 is enabled to be used in conjunction  
with a first LO signal to down convert a GPS signal to an IF signal and in conjunction  
with a second LO signal to down convert a PCS signal to an IF signal.

5 Referring now to Fig. 2, another embodiment will now be described, in which a single, first BPF 24 is enabled to filter either an IF signal from a GPS signal or an IF signal from a cellular band signal. Thus, an input 70 from a cellular duplexer (not shown) is coupled to a first LNA 75. The first LNA 75 is coupled to a second BPF 79. The second BPF 79 is coupled to a first input 83 of a first mixer 87. A second input 43 of the  
10 first mixer 87 is coupled to a divide by two circuit 53. The divide by two circuit 53 is coupled to an RF output 26 of a dual band local oscillator 28. An output 89 of the first mixer 87 is coupled to the first filter 24. In this way, the same filter, the first filter 24, is enabled to be used to filter an IF signal that is indicative of either the GPS signal or the  
15 cellular signal.

15 The cellular signal may, optionally, be an FM signal, rather than a CDMA signal. In this case, the cellular signal will be processed by other baseband processing circuitry (not shown). For signal quality reasons, not fully described here, FM signals are processed also through a separate mixer 49 and IF filter 51 than the CDMA signals. These elements are shown for completeness. Thus, the second BPF 79 is also coupled to  
20 a first input 41 of a second mixer 49. The divide by two circuit 53 is coupled to a second input 45 of the second mixer 49. An output 47 of the second mixer 49 is coupled to a third BPF 51. The GPS signal is coupled to the IF filter 24 analogously to how the GPS signal is coupled to the IF filter 21 in Fig. 1. This is not described again here with reference to Fig. 2. Note that a band select switch 30 is optional for the provision of a  
25 PCS receive path. A GPS filter 32 may be directly coupled to a mixer 35 for downconversion to an IF. Alternatively for tri-mode phone, the GPS signal may be coupled to the mixer 35 through a diplexer (not shown) or a duplexer (not shown) in lieu of the switch 30.

5 Another embodiment is shown in Fig. 3. Components similar to those already described will not be described in detail. A diplexer 81 may be used in place of the band select switch 26, shown in Fig. 1. The diplexer transmits both the PCS signal and the GPS signal to the first mixer 46. In this case, both the PCS signal and the GPS signal are converted to an IF signal by the mixer 46. But only one of the PCS signal and the GPS  
10 signal is converted to an IF signal that is in the passband of the third bandpass filter 21. Which of the PCS signal and the GPS signal is converted to an IF signal in the passband of the third bandpass filter 21 depends upon which local oscillator signal is transmitted to the input of the first mixer 46. Which local oscillator signal is transmitted to the first mixer 46 depends upon which local oscillator signal is selected by the GPS control signal  
15 generator 20.

Another embodiment is shown in Fig. 4. Again, similar parts to those already described will not be described in detail. A duplexer 92 may replace the first bandpass filter 22, the second bandpass filter 62 and the band select switch 38 shown in Fig. 1 or first and second band pass filters and the diplexer 81 shown in Fig. 3. The duplexer 92 receives both the GPS signal and the PCS signal and filters them, transmitting only the GPS signal and the PCS signal to the first mixer 46. Operation of the mixer 46 and filter 21 are as described previously with reference to Fig. 3.

Preferably, the GPS control signal generator 37 is used to switch the GPS and PCS LNAs' on and off, as shown in Fig. 5a. When the GPS control signal is on, the GPS  
25 LNA 18 is powered on and the PCS LNA 54 is powered off. Conversely, when the GPS control signal is off, the GPS LNA 18 is powered off and the PCS LNA 54 is powered on. Then, regardless of whether a duplexer, a diplexer, or a switch is used for selecting

5 the signals to be coupled to the mixer, only the selected signal reaches the mixer, and consequently, only the selected IF signal reaches the IF filter.

The powering on and off of the GPS LNA and the PCS LNA may be accomplished as shown in Fig. 5a. When the GPS control signal is on, a switch 11 is in a position to transmit current from a power supply 40 to the power line 13 of the GPS LNA

10 18. In this position of the switch 11, the power supply 40 is not coupled to the power line 16 of the PCS LNA 54. Conversely, when the GPS control signal is off, the switch 11 is in a position to transmit current from the power supply 40 to the power line 16 of the PCS LNA 54 and not to the power line 13 of the GPS LNA 18. It will be appreciated that other components and methods may be used to power on and off the LNA's. Indeed in some  
15 designs it may not be necessary to switch power on and off to the LNA's as the LO signal effectively selects which signal is converted to the IF frequency.

It will be appreciated that while the embodiments described with reference to Figs. 1-5 are separate embodiments, they may be combined in several ways. For example, a single mixer may be used to downconvert PCS and GPS signals to an IF signal, as

20 shown in Fig. 1, while cellular CDMA may be downconverted using a separate mixer as shown in Fig. 2, but may use the same IF filter as used by the PCS and GPS signals. Thus, Figs. 1 and 2 can be combined to yield a receiver portion wherein a single mixer is used for GPS and PCS signals and a single IF filter is used for GPS, PCS and cellular CDMA signals.

25 Further its is possible to use a single mixer for all three bands (Cellular, GPS and PCS), providing the mixer is preceded by the requisite LNA and RF filter. Further still, a single mixer may be used for more or different bands, e.g. 3G CDMA at about 2.2 GHz, DCS at about 1.8 GHz or GSM about at 800 MHz.

5 It may be necessary to use a passive mixer to mix all the bands of interest. Present  
wireless communication devices use active mixers. As is well known in the art, an active  
mixer has a relatively narrowband response. Such a response is shown if Fig. 5b. The  
response may be broad enough to mix both PCS and GPS, but not broad enough to also  
mix cellular CDMA. An active mixer has a typical gain in the region of interest of  
10 between 10 and 12 dB.

A passive mixer has a more flat response, as shown in Fig. 5c. This allows for  
mixing of a broader range of frequencies. However, a passive mixer has a conversion  
loss, as shown in Fig. 5c. The conversion loss of a typical passive mixer is typically 6 to  
8 dB, or a gain of -8 dB. Thus, there is a loss of between about 18 and 20 dB incurred by  
15 switching from an active to a passive mixer. A counterbalancing gain of about 18 to 20  
dB is required to make up for the loss of a passive mixer as compared to an active mixer.  
An additional amplifiers can be used to provide the gain required.

A receiver portion using a passive mixer to down convert more than two signals  
to an intermediate frequency signal will now be described with reference to Fig. 5d.  
20 Advantageously, this receiver portion re-uses a single mixer for each of several  
frequencies. Example frequencies include about 2.2 GHz for 3G CDMA, about 1.9 GHz  
for PCS, about 1.8 GHz for DCS, about 1.575 GHz for GPS, about 900 MHz for cellular  
CDMA and about 800 MHz for GSM. All of these frequencies can be down converted to  
a lower frequency signal by one mixer. It will be understood by those skilled in the art  
25 that this list is not exhaustive, but is intended by way of example only. Other frequencies  
could also be down converted to a lower frequency signal by the same mixer.

Referring now to Fig. 5d, four input lines 122, 123, 124 and 125 are shown  
coupled to four LNA's 128, 129, 130 and 131. Any of the signals of interest, such as, for

5 example, 3G CDMA, PCS, GPS may be coupled individually to these input lines. The LNA's 128, 129, 130 and 131 are coupled to four BPF's 135, 136, 137 and 138.

10 Optionally, there may also be more input lines, LNA's and BPF's (not shown) for accommodating more than four signals. The BPF's 135, 136, 137 and 138 are coupled to a switch 141. The switch is used to select between the input lines 122, 123, 124 and 125.

15 The output to the switch is coupled to a mixer 142. Optionally, an LNA 143 is coupled between the switch 141 and the mixer 142. In another option, an LNA 144 is coupled between the mixer 142 and an IF signal line 147. In yet another option, both LNA 143 and LNA 144 are coupled on either side of mixer 142. Either or both of LNA's 143 and 144 make up for the increased loss of the passive mixer 142 as compared to an active

20 mixer. In this way, a single mixer 142 can be advantageously used to mix many bands down to an IF. The bands are not constrained to be near each other in frequency.

It will be appreciated by one skilled in the art that the increased loss of the passive mixer 142 as compared to an active mixer could be made up for in other ways. The LNA's 143 and 144 are shown by way of example only. It will also be understood by one skilled in the art that more than four signals may be downconverted to an IF in this way. More input lines, more LNA's and more BPF's (not shown) would be coupled to the switch 141. The additional input lines, LNA's and BPF's are indicated by the dashed line 149.

25 A method of converting a GPS signal to an intermediate frequency signal is shown in Fig. 6. First, in step 305, a mixer is provided and configured to receive a PCS signal and a GPS signal. This mixer, for example, could be a mixer 46 such as shown in Fig. 1. It could, for example, be configured as shown in any of Figs. 1-4, or in any other way that is well known in the art for providing two different signals to a mixer.

5           Second, in step 310, the PCS signal is mixed, using the mixer, with a first local oscillator signal. The first local oscillator signal may come from a dual band local oscillator 66 as shown in Fig. 1. Alternatively, the first local oscillator signal may be coupled to the mixer in any configuration well known in the art.

10         Third, in step 315, a GPS control signal, also known as a GPS control signal, is generated. This GPS control signal may be a result of a manual switch manipulated by a wireless communication device user or by any software or hardware method that is known in the art of electronic communication. The GPS control signal indicates whether the communication device is to be used at the moment in GPS mode or PCS mode.

15         Fourth, in step 320, the PCS signal is decoupled from the mixer, responsive to the GPS control signal. A band select switch may be used to decouple the PCS signal from the mixer, such as is shown in Fig. 1. Alternatively, any known method of decoupling RF signals from mixers may be used.

20         Fifth, in step 325, the mixer is used to mix the GPS signal with a second local oscillator signal, producing an intermediate frequency signal.

25         A method of converting a GPS signal to one IF signal and a PCS to another IF signal using the same mixer is shown in Fig. 7. An IF filter is used to select which IF signal to use for further processing. First, in step 405, a mixer is provided and configured to receive a PCS signal and GPS signal. This mixer, for example, could be a mixer 46 such as shown in Fig. 3. It could, for example, be configured as shown in either of Figs. 3-4, or in any other way that is well known in the art for providing two different signals to a mixer.

Second, in step 410, a GPS signal and a PCS signal are coupled to the mixer.  
Third, in step 415, a GPS control signal, also known as a GPS control signal, is

5 generated. This GPS control signal may be a result of a manual switch manipulated by a wireless communication device user or by any software or hardware method that is known in the art of electronic communication. The GPS control signal indicates whether the communication device is to be used at the moment in GPS mode or PCS mode.

Fourth, in step 420, either a first or a second local oscillator (LO) signal is  
10 coupled to the mixer, responsive to the GPS control signal. The first and second local oscillator signals may come from a dual band local oscillator 66 as shown in Fig. 1. Alternatively, the first local oscillator signal may be coupled to the mixer in any configuration well known in the art.

Fifth, in step 425, the GPS signal and the PCS signal are mixed with the first or  
15 second local oscillator signal by the mixer, depending on which local oscillator signal is coupled to the mixer. Regardless of which local oscillator signal is coupled to the mixer, it will be mixed with both the GPS and the PCS signals.

Sixth, in step 430, either the first or the second IF signal is selected by the IF filter for further processing. In this way, one IF filter is enabled to be used for both GPS and  
20 PCS IF signal filtering.

To make one filter usable for both GPS and PCS IF filtering, the local oscillator frequencies should be carefully chosen. A common IF is 183.6 MHz. To obtain this IF, a local oscillator frequency in the region of 2143.6 MHz is commonly used in conjunction with the PCS signal. This is injected on the high side of the PCS Rx signal, commonly in  
25 the region of 1960 MHz, giving an IF of 183.6 MHz. Thus, a local oscillator signal at 2143.6 MHz can be referred to as a PCS local oscillator signal.

To obtain an IF signal from a GPS signal, commonly at 1575.42 MHz, a low side injection of a local oscillator can be used, with a frequency of 1391.82 MHz. Thus, a

5 local oscillator signal at 1391.82 MHz can be referred to as a GPS local oscillator signal. This way, whether the 1391.82 MHz local oscillator or the 2143.6 MHz local oscillator is coupled to the mixer, only one signal in the passband of the IF filter, at 183.6 MHz, will pass through the IF filter. It will be understood that alternative frequencies and injection schemes can be implemented and are within the scope of this invention. It is preferred

10 that the GPS signal does not create harmonic or other undesired signals in the range of the IF filter when mixed with the PCS local oscillator signal. It is also preferred that the PCS signal does not create harmonic or other undesired signals in the range of the IF filter when mixed with the GPS local oscillator signal.

It will be understood that the foregoing embodiments are intended by way of  
15 example only. It is to be understood that there are many ways of implementing the invention. The invention is only intended to be limited by the claims that follow.